Few internal iliac artery aneurysms rupture under 4 cm

Laine, Matti T.

2017-01

Laine , M T , Bjoerck , M , Beiles , C B , Szeberin , Z , Thomson , I , Altreuther , M , Debus , E S , Mani , K , Menyhei , G & Venermo , M 2017 , ' Few internal iliac artery aneurysms rupture under 4 cm ' , Journal of Vascular Surgery , vol. 65 , no. 1 , pp. 76-81 . https://doi.org/10.1016/j.jvs.2016.06.1

http://hdl.handle.net/10138/231196
https://doi.org/10.1016/j.jvs.2016.06.109

publishedVersion

Few internal iliac artery aneurysms rupture under 4 cm

Matti T. Laine, MD,[a] Martin Björck, MD, PhD,[b] C. Barry Beiles, MB BCh, FRACS(Vasc),[c] Zoltán Szeberin, MD, PhD,[d] Ian Thomson, MBChB, FRACS,[e] Martin Altreuther, MD,[f] E. Sebastian Debus, MD, PhD,[g] Kevin Mani, MD, PhD,[b] Gábor Menyhei, MD, PhD,[h] *and* Maarit Venermo, MD, PhD,[a] *Helsinki, Finland; Uppsala, Sweden; Melbourne, Victoria, Australia; Budapest and Pécs, Hungary; Dunedin, New Zealand; Trondheim, Norway; and Hamburg, Germany*

ABSTRACT

Objective: This study investigated the diameter of internal iliac artery (IIA) aneurysms (IIAAs) at the time of rupture to evaluate whether the current threshold diameter for elective repair of 3 cm is reasonable. The prevalence of concomitant aneurysms and results of surgical treatment were also investigated.

Methods: This was a retrospective analysis of patients with ruptured IIAA from seven countries. The patients were collected from vascular registries and patient records of 28 vascular centers. Computed tomography images taken at the time of rupture were analyzed, and maximal diameters of the ruptured IIA and other aortoiliac arteries were measured. Data on the type of surgical treatment, mortality at 30 days, and follow-up were collected.

Results: Sixty-three patients (55 men and 8 women) were identified, operated on from 2002 to 2015. The patients were a mean age of 76.6 years (standard deviation, 9.0; range 48-93 years). A concomitant common iliac artery aneurysm was present in 65.0%, 41.7% had a concomitant abdominal aortic aneurysm, and 36.7% had both. IIAA was isolated in 30.0%. The mean maximal diameter of the ruptured artery was 68.4 mm (standard deviation, 20.5 mm; median, 67.0 mm; range, 25-116 mm). One rupture occurred at <3 cm and four at <4 cm (6.3% of all ruptures). All patients were treated, 73.0% by open repair and 27.0% by endovascular repair. The 30-day mortality was 12.7%. Median follow-up was 18.3 months (interquartile range, 2.0-48.3 months). The 1-year Kaplan-Meier estimate for survival was 74.5% (standard error, 5.7%).

Conclusions: IIAA is an uncommon condition and mostly coexists with other aortoiliac aneurysms. Follow-up until a diameter of 4 cm seems justified, at least in elderly men, although lack of surveillance data precludes firm conclusions. The mortality was low compared with previously published figures and lower than mortality in patients with ruptured abdominal aortic aneurysm. (J Vasc Surg 2017;65:76-81.)

Abdominal aortic aneurysm (AAA) is the most common and studied aneurysm. Aneurysms of the iliac arteries are found considerably less often, and epidemiologic data on these do not exist. In many cases iliac artery aneurysms coexist with aortic aneurysms: ~10% to 20% of patients with AAA also have a concomitant aneurysm in the iliac arteries.[1] The artery most often affected is the common iliac artery (CIA), followed by the internal iliac artery (IIA), also called the hypogastric artery. In the case of isolated aneurysms in the iliac arteries, without involvement of the aorta, the most common location is the IIA.[2] Aneurysms of the external iliac artery are extremely rare, possibly because these arteries originate later in development from a different cell population than the distal aorta and the CIA and IIA. Studies on IIA aneurysms (IIAAs) are scarce owing to the rarity of the condition. The existing literature consists primarily of case reports and small patient series. No prospective studies on IAAs exist.

According to the literature, IAAs have a high rupture and mortality rate even in elective cases, possibly because of their deep location in the pelvis.[3] The etiology and risk factors of IAA seem to be the same as AAA.[4] Iliac aneurysms are mostly degenerative but can also be mycotic or caused by genetic disorders such as Marfan or Ehlers-Danlos syndromes. Traumatic aneurysms in the iliac arteries have also been described; for example, caused by iatrogenic trauma from hip, lumbar, or gynecologic operations. A mainly historical subpopulation of young women with IIAA caused by trauma from pregnancy and delivery has been described.[5,6]

From the Department of Vascular Surgery, University of Helsinki and Helsinki University Hospital, Helsinki[a]; the Department of Surgical Sciences, Section of Vascular Surgery, Uppsala University, Uppsala[b]; the Department of Vascular Surgery, Western Hospital, Melbourne[c]; the Department of Vascular Surgery, Semmelweis University, Budapest[d]; the Department of Surgical Sciences, University of Otago, Dunedin[e]; the Department of Vascular Surgery, Surgical Clinic, St. Olavs Hospital, Trondheim[f]; the Department of Vascular Medicine, University Heart Center, Hamburg[g]; and the Department of Vascular Surgery, University Pécs Medical Centre, Pécs.[h]

M.T.L. received salary from the grant of the Special Governmental Subsidy for the Health Sciences Research in Finland to work on this project.

Author conflict of interest: none.

Presented at the Twenty-ninth Annual Meeting of European Society for Vascular Surgery, Porto, Portugal, September 23-25, 2015.

Correspondence: Matti T. Laine, MD, Department of Vascular Surgery, Helsinki University Hospital, PO Box 340, FI-00029 HUS, Helsinki, Finland (e-mail: matti.laine@hus.fi).

The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214

http://dx.doi.org/10.1016/j.jvs.2016.06.109

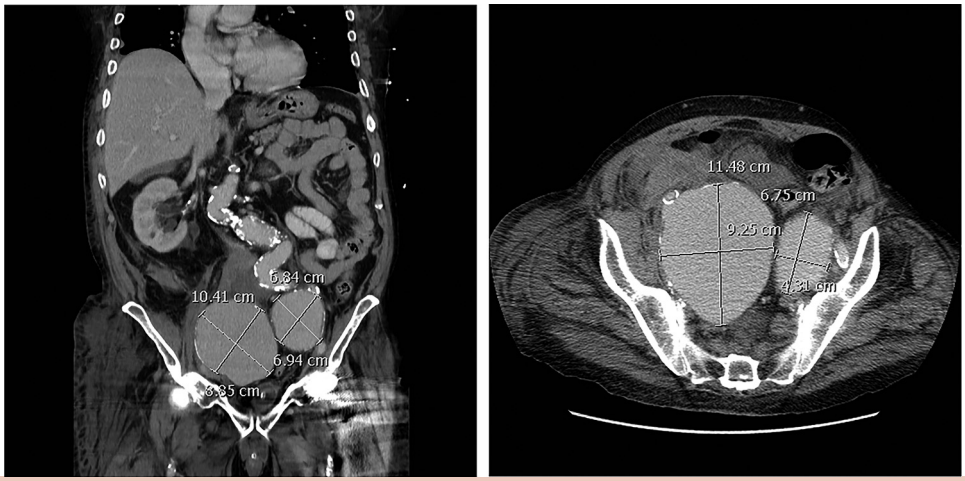

Fig 1. Computed tomography (CT) images of a patient show large internal iliac artery (IIA) aneurysms (IIAAs) on both sides, with rupture on the right side. Diameter measurements are shown for **(left)** axial and **(right)** coronal planes.

IAAs cause symptoms more often than AAA because of compression of pelvic structures such as ureters, bladder, veins, or lumbar nerves. Wilhelm et al[7] reported that 53% of published isolated IIAA cases were symptomatic, not including the ruptured ones (31%). The high proportion of symptomatic patients in these older reports may partly be explained, however, by the fact that most of these cases were from time before widespread use of modern imaging. IIAA are not easily discovered with clinical examination because of their location[8] but are detected increasingly often as a result of imaging and screening programs.

Because the studies on IIAAs are scarce, the natural history is virtually unknown. A widely used threshold for elective repair is 3 cm, originally suggested by McCready et al[9] because their series did not include any ruptures under that diameter. However, only seven ruptures were included in that report. The reference list of this article illustrates that most of the papers on this subject were published when open repair was the only treatment option. Nowadays endovascular treatment is the first option in many centers.[10]

The aim of this study was to investigate at what diameter IIAAs tend to rupture and whether the current operative threshold of 3 cm is rational. Secondary aims were to assess the prevalence of concomitant aortoiliac aneurysms, treatment patterns, and the results of treatment.

METHODS

This was a retrospective analysis of patients who sustained a rupture of an IIAA. Patient data were collected from hospital records and vascular registries, with 28 vascular centers from seven countries contributing to the study. Patients were from Hungary (3 hospitals), Sweden (10 hospitals), Australia (10 hospitals), New Zealand (2 hospitals), Norway (1 hospital), Finland (1 hospital), and Germany (1 hospital). The Helsinki University Hospital Institutional Review Board approved the study. No informed consent was obtained from patients because the study was a retrospective register study.

The collected data included age, gender, the maximum diameter of the ruptured IIAA measured from a computed tomography (CT) scan, and the diameters of the contralateral IIA, contralateral and ipsilateral CIA, and infrarenal aorta. The measurements were made at the point where the diameter was the largest, with two dimensions measured at that same plane (Fig 1). When available, the investigators reviewed and measured the CT images; in other cases, measurements were taken from original radiologist's reports. Three patients did not undergo CT imaging.

According to the Society for Vascular Surgery Ad Hoc Committee on Reporting Standards, an aneurysm is defined as a focal dilatation of >50% in diameter compared with the normal diameter of the corresponding artery based on measurements on healthy individuals.[11] These guidelines states that normal IIA is 0.5 (standard deviation [SD] 0.2) cm in diameter, and thus, diameters >0.8 cm should be considered aneurysmatic; for the CIA, the normal value is 1.2 cm, and 1.8 cm would be aneurysmatic. In this study, we have defined an aneurysm as a maximal diameter >18 mm in both the CIA and IIAs and >30 mm in the infrarenal aorta. A previously treated AAA or CIA aneurysm (CIAA) was classified as a concomitant AAA/CIAA. Mortality data at 30 days were collected along with data on follow-up length and all-cause mortality.

Statistical analysis was performed using SPSS 22 software (IBM Corp, Armonk, NY). Proportions were compared with χ^2, and the Student *t*-test was used for comparisons between groups of continuous variables. The survival curve was generated with the Kaplan-Meier method.

RESULTS

We identified 63 patients (55 men and 8 women [12.7%]) in 28 centers across seven countries from 2002 to 2015 (Table I). Six patients (9.5%) were operated on during

Table I. Patient characteristics

Variables	No. (%) or mean (range) (N = 63)
Age, years	76.6 (48-93)
Sex	
Male	55 (87)
Female	8 (13)
Country	
Hungary	15 (24)
Australia	14 (22)
Sweden	12 (19)
New Zealand	7 (11)
Norway	6 (10)
Finland	6 (10)
Germany	3 (5)

Table II. Anatomical distribution of aneurysms and treatment options

Variable	No. with data[a] (N = 63)	No. (%)
Anatomy		
IIAA		
Right	63	30 (47.6)
Left	63	33 (52.4)
Isolated	60	18 (30.0)
Bilateral	57	25 (43.9)
Concurrent CIAA	60	39 (65.0)
Concurrent AAA	60	25 (41.7)
Concurrent CIAA and AAA	60	22 (36.7)
Treatment option	63	
Open surgery		46 (73.0)
Endovascular treatment		17 (27.0)
30-day mortality	63	8 (12.7)
Open surgery		6 (13.0)
Endovascular treatment		2 (11.8)

AAA, Abdominal aortic aneurysm; *CIAA*, common iliac artery aneurysm; *IIAA*, internal iliac artery aneurysm.
[a]Signifies the number of patients (of the 63 patients in total) for whom the required data were available.

2002 to 2005, 18 (28.6%) during 2006 to 2010, and 39 (61.9%) during 2011 to 2015. Patients were a mean age of 76.6 (SD 9.0) years (range, 48-93 years) with no difference between men and women (76.2 vs 79.8 years, respectively; $P = .296$). IIAAs were as common on the left as on the right side. Bilateral IIAA was present in 25 patients (43.9%). CIAA was present in 39 patients (65.0%), AAA in 25 patients (41.7%), and 22 patients (36.7%) had CIAA and AAA in addition to the ruptured IIAA. An isolated IIAA was present in 18 patients (30.0%; Table II).

The mean maximal diameter of the ruptured IIAA was 68.4 (SD, 20.5) mm (median, 67.0 mm; range, 25-116 mm). There was no significant difference in diameter between men and women (mean 69.2 mm [SD, 20.9, median, 70.0; range 25-116 mm] and 62.3 mm [SD, 16.8; median, 62.0; range, 42-91 mm], respectively; $P = .406$). The mean diameter was 67.6 (SD, 21.8) mm for those aged <75 years (n = 25) and 69.6 (SD, 19.8) mm for those ≥75 years (n = 38; $P = .705$). There was one rupture <3 cm (1.6% of ruptures) and four <4 cm (6.3%). The isolated IIAA tended to be smaller (60.8 mm; SD, 18.3; median, 56.5; range 38-110 mm) than the IIAA with concomitant aneurysms (71.6 mm; SD, 20.7; median, 75.5; range 25-116 mm; $P = .059$). There was no difference between these groups in patient age (77.3 vs 76.7 years; $P = .798$). The diameter of the ruptured IIAA was on average 4.4 times (range, 0.7-11.4 times) larger than the contralateral IIA and 5.9 times (range, 2.3-11.4 times) larger when the contralateral IIA was not aneurysmatic. The contralateral aneurysm in one patient was larger than the ruptured one. An IIAA was diagnosed in seven patients before rupture. All of those were >3 cm in diameter but were not operated on before rupture. One of the patients had previously declined treatment, and one had a rupture of a previously coiled IIAA.

All patients underwent surgical treatment for rupture with open (46 patients [73.0%]) or endovascular (17 patients [27.0%]) repair. Although specific details on the operations performed were available in only a few cases, open repair was primarily performed by proximal ligation and endoaneurysmorrhaphy or by placing a prosthesis interposition graft from the CIA or aorta to the external iliac or femoral artery. The primary endovascular technique was coiling or embolizing the IIAA and placing a covered stent or a stent graft over the ostium of the IIA. In some cases, only proximal ligation or proximal control with covered stent or stent graft was performed.

The overall 30-day mortality was 12.7%: 13.0% in the open group and 11.8% in the endovascular group. The patients in the endovascular group were older than patients in the open surgical group (80.9 vs 75.1 years; $P = .021$), but there was no difference in aneurysm diameter (64.4 vs 69.8 mm; $P = .269$) between the groups. Median follow-up was 18.3 months (interquartile range [IQR], 2.0-48.3 months) overall, 16.3 months (IQR, 3.2-45.8 months) for the open surgery group, and 21.4 months (IQR, 1.5-58.5 months) for endovascular group. At the end of follow-up, 35 patients (55.6%) were alive, 56.5% in the open surgery group and 52.9% in the endovascular group ($P = .800$). Kaplan-Meier survival at 1 and 5 years was 74.5% (standard error, 5.7%) and 50.6% (standard error, 7.8%), respectively. The Kaplan-Meier survival curve is shown in Fig 2.

Eight patients died during the first 30 postoperative days. Death during that time occurred at a median of 1 day (IQR, 0-6.25 days). Causes of death were related to the operation or to the ruptured AAA (RAAA). The cause of death of one patient, who died on the 18th postoperative day, was unknown. An additional 19 patients

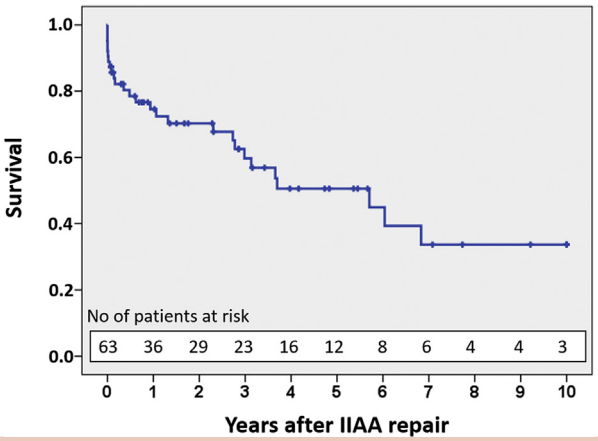

Fig 2. Kaplan-Meier curve shows survival after internal iliac artery (IIA) aneurysm (*IIAA*) repair.

died >30 days, mainly of cardiovascular causes: 3 died of stroke, 3 died of cardiac causes, and 1 died of mesenteric ischemia. Additional causes of death were lung cancer, sepsis related to retroperitoneal hematoma, pneumonia, sigmoid colon perforation, and rupture of a contralateral IIAA. The cause of death in eight patients remained unknown.

DISCUSSION

To our knowledge, this is the largest series on ruptured IIAA and has identified retrospectively 63 patients in 28 hospitals across seven countries between 2002 and 2015. The diameters of the ruptured aneurysms seem to be in line with previously published data. The mean diameter of aneurysm at the time of rupture was almost 7 cm. In nearly every third case, the IIAA was isolated. These isolated IIAAs were smaller, but the reason for this is unknown. It might be that the etiology of isolated IIAA differs from that of the aneurysms involving the entire aortoiliac vasculature or it might be because of the different hemodynamic situation caused by proximal aneurysms. Because of the small number of women in the study, no conclusions can be drawn about possible differences between genders. It would seem reasonable, however, to assume that the increased risk of rupture observed in women with AAA may also exist for women with IIAA.[12]

In the review by Wilhelm et al,[7] there were more than twice as many left-sided IIAA as right-sided. They included all published patients with isolated IIAA, both ruptured (n = 17) and nonruptured (n = 38).[7] In contrast, the present study did not note an increased number of ruptured IIAA on the left side. Small series, such as the one described by Wilhelm et al,[7] are associated with type I statistical error.

The recommended repair threshold for IIAA is commonly >3 cm, which is not based on any evidence.[9] In our data, there was only one patient with a ruptured IIAA <3 cm and four patients <4 cm. This represents 6% of all ruptures, which is quite similar to the 8% of AAA ruptures observed at <5.5 cm in a series of 336 RAAA patients with CT images confirming rupture in two vascular centers in Finland.[13] Although the data from the present investigation do not allow the calculation of rupture risk for IIAA according to diameter, because we lack a prospective cohort design, the results indicate that the rupture risk of IIAA <4 cm could be similar to AAA <5.5 cm (Fig 3). Thus, changing the threshold of operative treatment up to 4 cm for degenerative IIAA is probably associated with an acceptable risk. We emphasize, however, that the threshold for AAA repair is based on Level 1 evidence (multiple randomized controlled trials),[12,14] and the data of this investigation are based on Level 4 evidence.

The previously published survival rates for patients treated surgically for IIAA have been quite poor, especially after rupture. Mortality rates in ruptured cases have been reported to be >50%,[2,3,7] although some evidence suggests that the contemporary mortality rate may be lower with endovascular techniques.[15] Operative mortality rates for nonruptured patients have been reported as being >10%; however, these seem to be lower as well in more recent reports.[7] In a Japanese report of ruptured and nonruptured patients (26 patients), including aneurysms of both the CIAs and IIAs managed by open repair, the 30-day mortality was only 3.9% (1 patient), and there were no additional deaths during the 5-year follow-up.[16] Only seven patients, however, had IIAA, and only three of these were ruptures. The single fatality actually occurred in a patient undergoing repair for a nonruptured IIAA.

Our study indicates that the results of treatment are not as poor as previously reported. The 30-day mortality was 12.7% (95% confidence interval, 4.5%-20.9%). A multivariable analysis could not be performed because the open and endovascular treatment groups were not randomized and because of the low number of patients in these groups. Thus, direct comparison between treatment methods is not reliable. Mortality in ruptured IIAA seems to be lower than in RAAA, where operative mortality is reported as 30% to 50%,[17-20] although falling mortality rates have recently been reported.[21,22] The 1-year all-cause mortality after ruptured IIAA was 25.5%. In comparison, 1-year mortality after RAAA in the Immediate Management of Patients With Ruptured Aneurysm: Open vs Endovascular Repair (IMPROVE) trial was 41.1% for the endovascularly treated group and 45.1% for the open repair group.[23]

Morbidity after endovascular and open surgery of the iliac arteries can include buttock claudication, buttock necrosis, impotence, and ischemia of the colon or the spinal cord.[24,25] The incidence of ischemic complications after occlusion of the IIAs in vascular surgery patients has been reported to be as high as 37.4%.[24] Ischemic morbidity from endovascular IIAA repair is likely higher than in AAA repair because, invariably, the IIA has to be

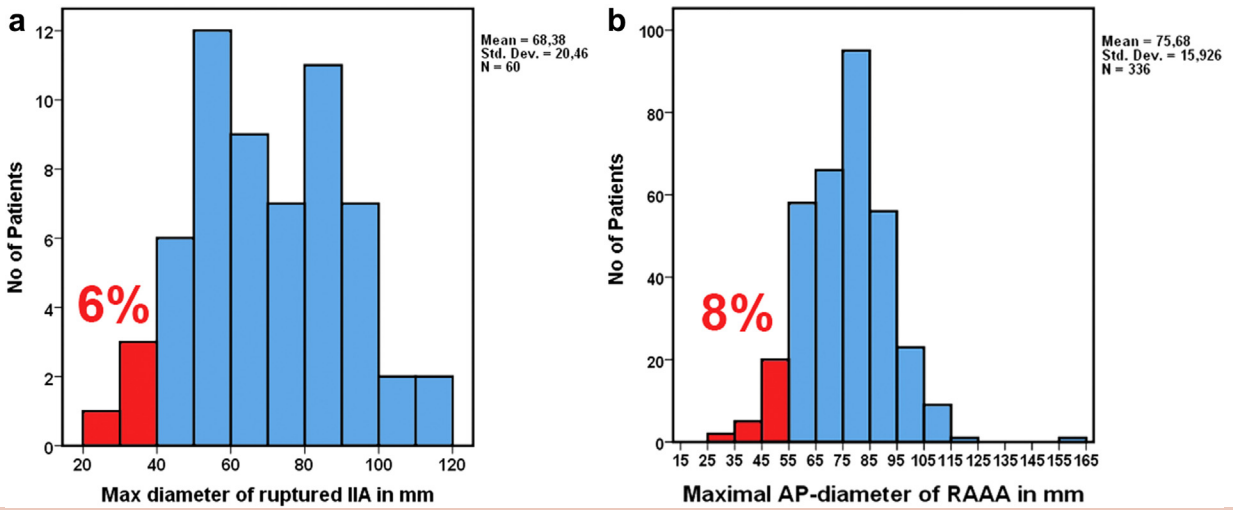

Fig 3. Comparison between ruptured internal iliac artery (*IIA*) aneurysm (IIAA) and ruptured abdominal aortic aneurysm (*RAAA*). **a,** Number of ruptured IIAA patients in relation to diameter at the time of rupture, with ruptures <4 cm in *red* (6% of all ruptures). **b,** Number of RAAA patients in relation to anteroposterior (*AP*) diameter at the time of rupture, with ruptures <5.5 cm in *red* (8% of all ruptures).

occluded, including distal branches of the artery, which compromises collateral blood flow.

A significant proportion of RAAA mortality comes from patients who die before reaching the hospital.[20] Because of its anatomical location, IIAA may be less likely to rupture into the free abdominal cavity and thus may likely present more often as contained ruptures than RAAA cases. This would probably translate to a lower immediate mortality than RAAA. Not having a more aggressive approach to treating IIAA than AAA would seem reasonable given the above considerations and the fact that mortality for emergency IIAA repair seems to be lower than previously anticipated and morbidity from elective operations can be considerable. With the current 3-cm threshold, it would seem that IIAA is treated more aggressively than AAA.

This study has some important limitations that may cause a bias of the results. Firstly, because the data were collected retrospectively, not all data points were available for all of the patients. Secondly, the data were collected in several centers by different individuals.

Great efforts were made to validate the measurements of the iliac arteries and the aorta by examining the CT images, whenever possible. Furthermore, the CT images were taken in an acute rupture setting, when patients are likely to be hypotensive, which may underestimate the actual aneurysm diameter prerupture. Thus, the actual diameter may have been even greater than reported in this study, further supporting our main conclusion that repair is probably not necessary before the IIAA diameter reaches 4 cm.

Patients were collected from vascular registries and hospital records and may not include all of the ruptured IIAA patients treated in all of the 28 hospitals during the study period. Also, IIAA ruptures may have been classified as ruptures of other concomitant aneurysms and not included for this reason. Patients not treated surgically were likely missed because all patients in this study were operated on.

Strengths of the study are the large number of patients studied and the availability of CT images for retrospective review of the images in most cases.

In the future, prospective data collection on long-term mortality and morbidity for those operated on as well as on high-risk IIAA patients—those not eligible for repair—would enhance the soundness of evidence. Owing to the rarity of this condition, a collaborative registry work might be the only way to enlighten the lack of knowledge in this situation.

CONCLUSIONS

This study shows that among patients with ruptured IIAA, the proportion of aneurysms <4 cm was low, which suggests that delaying operative treatment until a diameter of 4 cm may be safe, at least in elderly men, who constituted most of the IIAA patients in this study. Surgical results, in particular survival, seem to be better than in patients with RAAA.

The authors acknowledge the generosity of the vascular surgeons who operated on the studied patients and so generously shared their experience by entering the data into the different vascular registries that were used to identify the operations: Thomas Troëng, Joachim Starck, Olle Nelzen, Tal Hörer, Sverker Svensjö, Joakim Nordanstig, Johnny Steuer, Gábor Vallus, William Butcher, Nicole Organ, Nick Boyne, Damien Holdaway, Adrian Ling, Mauro Vicaretti, Lachie Maddock, Jon

Golledge, John Quinn, Justin Jedanyk, Dilip Naik, David Adams, Anwar Choudhary, Ilkka Kantonen, Sailaritta Vuorisalo, Katariina Noronen, Petteri Kauhanen, Christian-Alexander Behrendt, and all others involved in the treatment of the patients. The authors acknowledge Reijo Sund for invaluable statistical assistance.

AUTHOR CONTRIBUTIONS

Conception and design: ML, MB, CB, ZS, IT, MA, ED, KM, GM, MV

Analysis and interpretation: ML, MB, CB, ZS, IT, MA, ED, KM, GM, MV

Data collection: ML, MB, CB, ZS, IT, MA, ED, KM, GM, MV

Writing the article: ML, MV

Critical revision of the article: MB, CB, ZS, IT, MA, ED, KM, GM

Final approval of the article: ML, MB, CB, ZS, IT, MA, ED, KM, GM, MV

Statistical analysis: ML, MV

Obtained funding: MB, CB, ZS, IT, MA, ED, KM, GM, MV

Overall responsibility: ML

REFERENCES

1. Brunkwall J, Hauksson H, Bengtsson H, Bergqvist D, Takolander R, Bergentz SE. Solitary aneurysms of the iliac arterial system: an estimate of their frequency of occurrence. J Vasc Surg 1989;10:381-4.
2. Richardson JW, Greenfield LJ. Natural history and management of iliac aneurysms. J Vasc Surg 1988;8:165-71.
3. Krupski WC, Selzman CH, Floridia R, Strecker PK, Nehler MR, Whitehill TA. Contemporary management of isolated iliac aneurysms. J Vasc Surg 1998;28:1-11; discussion: 11-3.
4. Bjorck M, Wanhainen A. Pathophysiology of AAA: heredity vs environment. Prog Cardiovasc Dis 2013;56:2-6.
5. Maclaren A. XIV. Aneurism of the internal iliac: probably immediately following a severe instrumental delivery: operation and partial cure. Ann Surg 1913;58:269-70.
6. Brin BJ, Busuttil RW. Isolated hypogastric artery aneurysms. Arch Surg 1982;117:1329-33.
7. Wilhelm BJ, Sakharpe A, Ibrahim G, Baccaro LM, Fisher J. The 100-year evolution of the isolated internal iliac artery aneurysm. Ann Vasc Surg 2014;28:1070-7.
8. Dix FP, Titi M, Al-Khaffaf H. The isolated internal iliac artery aneurysm—a review. Eur J Vasc Endovasc Surg 2005;30:119-29.
9. McCready RA, Pairolero PC, Gilmore JC, Kazmier FJ, Cherry KJ Jr, Hollier LH. Isolated iliac artery aneurysms. Surgery 1983;93:688-93.
10. Cooper D, Odedra B, Haslam L, Earnshaw JJ. Endovascular management of isolated iliac artery aneurysms. J Cardiovasc Surg (Torino) 2015;56:579-86.
11. Johnston KW, Rutherford RB, Tilson MD, Shah DM, Hollier L, Stanley JC. Suggested standards for reporting on arterial aneurysms. Subcommittee on Reporting Standards for Arterial Aneurysms, Ad Hoc Committee on Reporting Standards, Society for Vascular Surgery and North American Chapter, International Society for Cardiovascular Surgery. J Vasc Surg 1991;13:444-50.
12. The United Kingdom Small Aneurysm Trial Participants. Long-term outcomes of immediate repair compared with surveillance of small abdominal aortic aneurysms. N Engl J Med 2002;346:1445-52.
13. Laine MT, Vanttinen T, Kantonen I, Halmesmaki K, Weselius EM, Laukontaus S, et al. Rupture of abdominal aortic aneurysms in patients under screening age and elective repair threshold. Eur J Vasc Endovasc Surg 2016;51:511-6.
14. Lederle FA, Wilson SE, Johnson GR, Reinke DB, Littooy FN, Acher CW, et al. Immediate repair compared with surveillance of small abdominal aortic aneurysms. N Engl J Med 2002;346:1437-44.
15. Morris ME, Huber KM, Maijub JG. Ruptured hypogastric artery aneurysms: a contemporary review. Vasc Endovasc Surg 2013;47:239-44.
16. Yamamoto H, Yamamoto F, Ishibashi K, Liu KX, Yamaura G, Chida Y, et al. Long-term outcomes of open surgical repair for ruptured iliac artery aneurysms. Ann Vasc Surg 2011;25:740-7.
17. Reimerink JJ, van der Laan MJ, Koelemay MJ, Balm R, Legemate DA. Systematic review and meta-analysis of population-based mortality from ruptured abdominal aortic aneurysm. Br J Surg 2013;100:1405-13.
18. Reite A, Soreide K, Ellingsen CL, Kvaloy JT, Vetrhus M. Epidemiology of ruptured abdominal aortic aneurysms in a well-defined Norwegian population with trends in incidence, intervention rate, and mortality. J Vasc Surg 2015;61:1168-74.
19. Karthikesalingam A, Holt PJ, Vidal-Diez A, Ozdemir BA, Poloniecki JD, Hinchliffe RJ, et al. Mortality from ruptured abdominal aortic aneurysms: clinical lessons from a comparison of outcomes in England and the USA. Lancet 2014;383:963-9.
20. Laine MT, Laukontaus S, Kantonen I, Venermo M. Population-based study of ruptured abdominal aortic aneurysm. Br J Surg 2016;103:1634-9.
21. Mani K, Bjorck M, Wanhainen A. Changes in the management of infrarenal abdominal aortic aneurysm disease in Sweden. Br J Surg 2013;100:638-44.
22. Mani K, Lees T, Beiles B, Jensen LP, Venermo M, Simo G, et al. Treatment of abdominal aortic aneurysm in nine countries 2005-2009: a Vascunet report. Eur J Vasc Endovasc Surg 2011;42:598-607.
23. IMPROVE Trial Investigators. Endovascular strategy or open repair for ruptured abdominal aortic aneurysm: one-year outcomes from the IMPROVE randomized trial. Eur Heart J 2015;36:2061-9.
24. Chitragari G, Schlosser FJ, Ochoa Chaar CI, Sumpio BE. Consequences of hypogastric artery ligation, embolization, or coverage. J Vasc Surg 2015;62:1340-7.e1.
25. Jean-Baptiste E, Brizzi S, Bartoli MA, Sadaghianloo N, Baque J, Magnan PE, et al. Pelvic ischemia and quality of life scores after interventional occlusion of the hypogastric artery in patients undergoing endovascular aortic aneurysm repair. J Vasc Surg 2014;60:40-9, 49.e1.

Submitted Mar 11, 2016; accepted Jun 23, 2016.